

Dec. 6, 1960

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2,963,703

METHOD AND MEANS FOR ANTENNA COUPLING

Filed Oct. 1, 1956

2 Sheets-Sheet 1

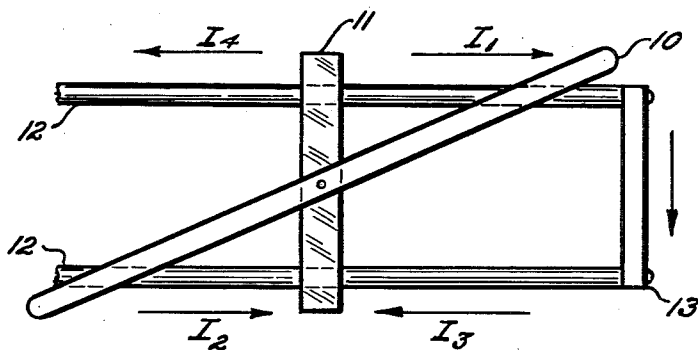


FIG. 1

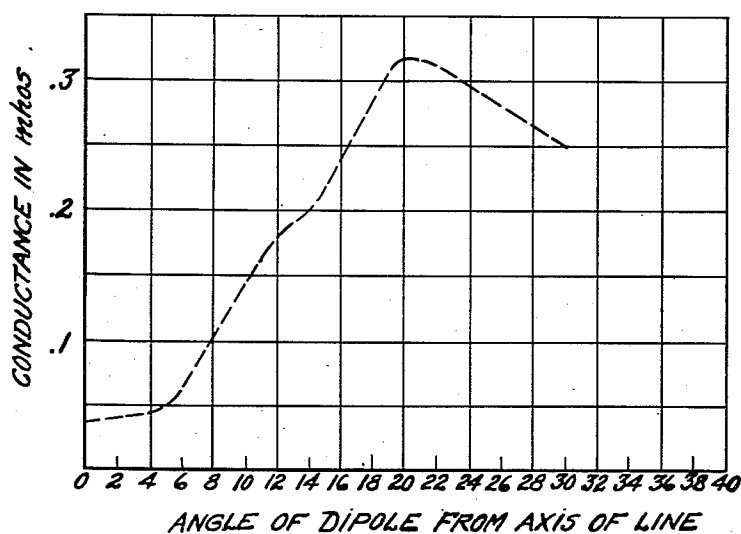


FIG. 2

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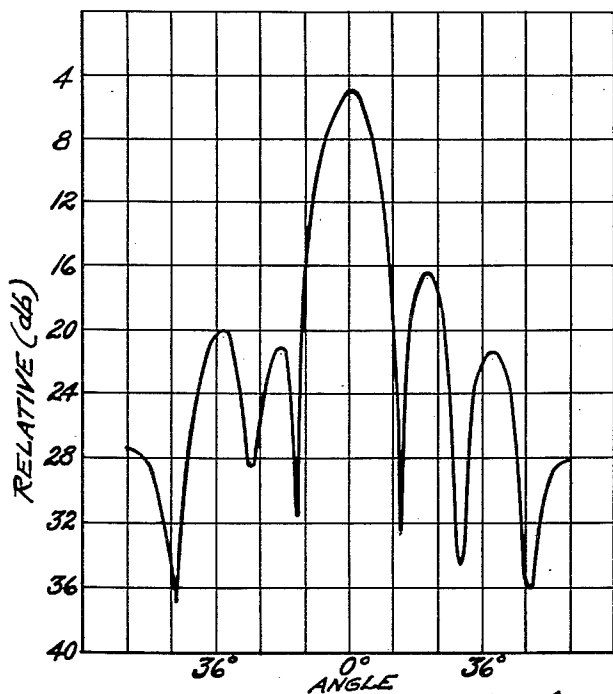
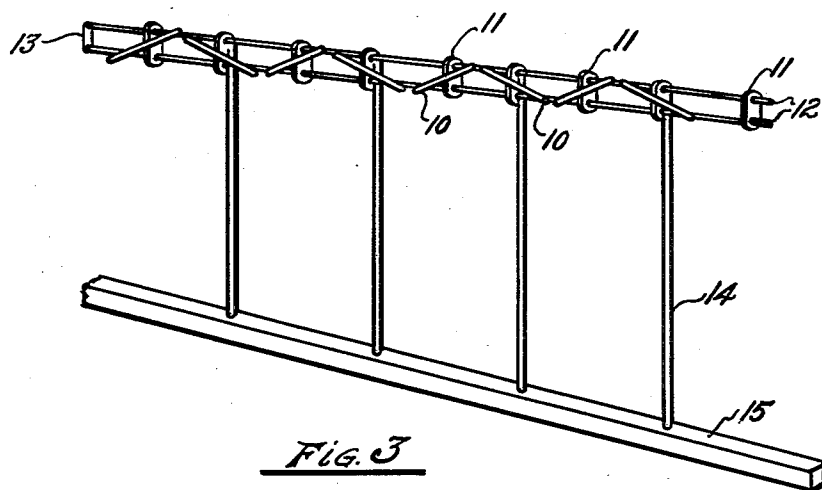
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METHOD AND MEANS FOR ANTENNA COUPLING

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1

2,963,703

METHOD AND MEANS FOR ANTENNA COUPLING

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Filed Oct. 1, 1956, Ser. No. 613,011

8 Claims. (Cl. 343-793)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to me of any royalty thereon.

This invention relates generally to antennas and more particularly to a new method of electromagnetically coupling radiating means to an open transmission line carrying equal and opposite currents which, when applied to antenna design, produces a new high-gain vertically polarized antenna that is suitable for omnidirectional (in azimuth) high power communication purposes.

The invention has particular utility in mattress type antenna arrays of any frequency and provides a feeding for UHF and VHF arrays where wave guide feeding is impractical and stripline feeding is complex.

Accordingly, this invention has for an object the provision of a simple method of feeding a large number of radiating elements.

Another object of the invention is the provision of a new method of electromagnetically coupling electric dipoles to a two-wire feeding line.

A further object of the invention is the provision of a novel method and means for controlling the pattern of an antenna.

A still further object of the invention is to enable controlled coupling to a two-wire line over a practical range of coupling (conductance) values without introducing any connections to or alterations in the feeding two-wire line.

Another object of the invention involves the provision of an antenna device capable of carrying high power.

Still another object of the invention involves a new method of and means for exciting a radiating element by its proximity to an open transmission line carrying equal and opposite currents.

A further object of the invention involves the production of an antenna device which is economical, easily fabricated and lends itself to economical weatherproofing techniques.

These and other advantages, features and objects of the invention will become more apparent from the following description taken in connection with the illustrative embodiments in the accompanying drawings, wherein:

Figure 1 is a diagrammatic representation of a two-wire line and dipole suitable for obtaining conductance data;

Figure 2 is a plotting of conductance vs. angular position of the dipole using the apparatus of Figure 1;

Figure 3 illustrates an eight element antenna constructed in accordance with the teachings of this invention; and

Figure 4 represents an E-plane pattern obtained from the antenna of Figure 3.

The coupling principle upon which this invention is based depends upon the orientation of a radiating element with respect to an open transmission line carrying equal and opposite currents. Although a two-wire line and dipole are utilized to illustrate the principle of the

2

invention, other transmission lines and dipoles, different from that shown in the figures, come within the concept, for example, a four-wire or parallel plate transmission line may be used with curved or other shaped radiating elements.

When a dipole is oriented parallel to the axis of a two-wire line, the currents in the line couple equally to the dipole, and there is zero radiation. Rotation of the dipole places alternate segments of the two-wires closer to the dipole such that the currents in the two-wire line electromagnetically couple unequally to the dipole to produce a radiation. When the radiation and coupling characteristics of a single rod on a two-wire line are known, the antenna performance can be determined by reference to known linear array theory. The coupling of a half-wave rod oriented with respect to a two-wire line depends upon the following parameters:

- (1) The rod length;
- (2) The frequency of the electromagnetic waves on the exciting two-wire line;
- (3) The spacing of the rod above the two-wire lines;
- (4) The diameter of the two-wire lines;
- (5) The spacing between centers of the two-wire lines;
- (6) The position of the rods with respect to the two-wire line terminations;
- (7) The intercoupling between adjacent elements; and
- (8) The angular rotation of the rod with respect to the axis of the two-wire line.

Figure 1 illustrates a dipole and two-wire line which demonstrate the principle of this invention. As dipole 10, which is rotatably mounted on a dielectric wafer 11, is displaced from a position parallel to the two-wire line 12, as illustrated, alternate segments of the two-wire line 12 are closer to the dipole 10 such that the currents I_1 and I_2 couple inductively to the dipole 10 more strongly than the remote currents I_3 and I_4 . Although a resonant line with a shorting bar 13, located $\lambda/4$ from the wafer 11, is depicted, the same relationships hold for a traveling wave. The dipole, when cut to the proper length, acts as a pure shunt conductance located at its midpoint, as seen by the transmission line.

Results obtainable by use of the test antenna of Figure 1 are plotted on the curve of Figure 2. Since the dielectric spacing wafer 11 causes negligible effect, and since no other objects were near the antenna, all the aforementioned parameters, except No. 8, are fixed. The curve of Figure 2 illustrates the coupling varying from approximately zero to a normalized conductance of about 0.3 mhos at an angle of 20° . Losses in the two-wire line account for the conductance at zero angle being greater than zero.

In order to construct an antenna utilizing the conductance data of Figure 2, the number of dipoles, their spacing and orientation with respect to the two-wire line and the position of the terminal impedance must be determined by the antenna pattern and impedance characteristics required of the antenna as a whole. By spacing the elements $\lambda/2$ apart, a 180° phase shift can be achieved between dipoles while plus and minus angles of rotation introduce a further phase shift of 180° .

The eight element array of Figure 3 illustrates an antenna whose pattern is broadside to the array. The dipoles 10 are mounted by conventional mounting means on dielectric spacer elements 11 which in turn are attached to the two-wire line 12. Supporting elements 14 and 15 are used to mount the antenna.

The E-plane, elevation pattern, of Figure 4 was produced by the antenna of Figure 3 and displays a beamwidth of about 13° and the side lobe at about -13 db, as would be predicted from a uniformly illuminated array. The input impedance would be more favorable with an array of the traveling wave type. Such an

array, with any desirable taper, is easily designed since conductances ranging from 0 to 0.3 g/Go are available. Since maximum coupling is obtained at about 20° of rotation of the dipole and most elements will be rotated less, cross polarization and mutual coupling between the elements on such arrays will be very small.

Thus it can be seen that by utilizing empirically obtained conductance data in conjunction with known linear array theory an antenna can be produced which consists of a balanced two-wire line feeding approximately $\lambda/2$ radiating rods or dipoles supported by dielectric wafers that also act as spacers for the two-wire line. No metallic contact or coupling mechanism, other than the electromagnetic coupling due to the proximity and orientation of the rods with respect to the two-wire line is used. By choosing the angular orientation of the dipoles from the conductance curve almost any total conductance can be obtained in an array. The number of elements that can be fed are limited only by the size of antenna that can be accommodated and the gain requirement.

The two-wire line may be made heavy enough to support the entire antenna or the antenna could be supported by other means, for example, by the use of wooden poles. It has been found that erection of the antenna over the ground or on a hangar roof enables the image to improve the gain. Light loading and the use of elements in even pairs keeps the amount of unbalance of the two-wire line to a minimum.

The pattern of the antenna can be controlled and made nearly omnidirectional in azimuth by installing the dipoles in pairs, i.e., referring to Figure 1, by placing an additional dipole 10 on the opposite face of wafer 11 to that on which the present dipole is attached such that its spacing from the two-wire line is the same as the dipole shown in the figure. By placing the additional dipole directly behind the dipole shown in Figure 1, the g/Go will be approximately doubled.

Although the invention has been described with reference to a particular embodiment, it will be understood to those skilled in the art that the invention is capable of a variety of alternative embodiments within the spirit and scope of the appended claims.

I claim:

1. A directive antenna system with controllable pattern comprising: a two-wire transmission line, the wires of said line being parallel to each other, a series of dielectric spacer elements along said line for supporting said wires in said parallel relationship, a series of dipoles positioned in a plane proximate and parallel to a plane through said wires, and mounting means for facilitating rotation of said dipoles about parallel axes located in a common plane perpendicular to the said plane through said two wires, and mid-way therebetween to establish predetermined angular relationships such that the sum of the conductances of the individual dipoles as determined by their angular positions equals a predetermined amount.

2. An antenna system as defined in claim 1, including means for establishing an omnidirectional pattern, said means comprising a second series of dipoles spaced from said two-wire line by an amount equal to the spacing of said first series of dipoles and attached to said spacer elements in predetermined angular positions.

3. A directive antenna system comprising a two-wire transmission line, the wires of said line being parallel to each other, a series of dielectric wafers for spacing said wires of said transmission line, said wafers being spaced along the transmission line at half-wavelength intervals, and a dipole mounted on each of said wafers such that a plane through said dipoles is parallel and proximate to a plane through the wires of the transmission line, said

dipoles having angular rotations about parallel axes located in a common plane perpendicular to both said first-named planes, and mid-way between said two wires, the degree of rotation being representative of conductance values such that the sum of said conductance values equals a predetermined conductance and variation in conductance along said transmission line will determine pattern.

4. An antenna system as defined in claim 3 wherein omnidirectionality is achieved by mounting dipoles on said wafers such that they are spaced from said transmission line by an amount equal to the spacing of said first series of dipoles and lying on a plane parallel to a plane through said wires of the transmission line and on the opposite side of the transmission line from the first series of dipoles.

5. A device for controllably coupling a radiating element to a transmission line comprising a transmission line having elements carrying equal and opposite currents, a radiating element, and means for supporting said radiating element for rotation about an axis located in a plane spaced equally from said two transmission line elements to establish adjustable orientation with respect to said transmission line such that said radiating element cooperates through space with said elements of said transmission line to achieve a predetermined amount of coupling.

6. A device for controllably coupling a radiating element to a transmission line comprising a radiating element, a transmission line carrying equal and opposite currents, and dielectric means facilitating rotation of said radiating element about an axis located in a plane spaced equally from the two current-carrying elements of said line for orienting said radiating element displaced from said transmission line such that portions of said radiating element are in an inductively coupled relationship with the currents in said transmission line elements.

7. A directive antenna system comprising a transmission line having elements carrying equal and opposite currents and at least one radiating element rotatable about an axis located in a plane spaced equally from the two current-carrying elements of said line such that the currents of said transmission line couple inductively to portions of said radiating element to cause radiation from said radiating element.

8. An antenna system comprising a transmission line having elements carrying equal and opposite currents and a series of radiating elements rotatable about axes located in a common plane equally distant from the two current-carrying elements of said transmission line and oriented with respect to the elements of said transmission line such that the currents in said transmission line elements couple unequally to portions of said radiating element, the amount of coupling being determined by the orientation of said radiating element.

References Cited in the file of this patent

UNITED STATES PATENTS

1,821,387	Lindenblad	Sept. 1, 1931
2,198,025	Davies et al.	Apr. 23, 1940
2,321,456	Byrne	June 8, 1943
2,413,836	Larson	Jan. 7, 1947
2,524,993	Rumsey	Oct. 10, 1950
2,527,609	Willoughby	Oct. 31, 1950
2,716,703	Kane	Aug. 30, 1955
2,881,436	Stavis	Apr. 7, 1959

OTHER REFERENCES

Pub. I, Antennas, Kraus, McGraw-Hill Book Co., Inc., 1950, pp. 294 and 356.